इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 14651 (1999): Multi Filamentary Niobium-titanium (Nbti) Superconductor Wires [MTD 9: Lead, Zinc, Cadmium, Tin, Antimony and their Alloys]

"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

BLANK PAGE

BRUTUM FULMEN

IGNORANTIA JURIS NON EXCUSAT

PROTECTED BY COPYRIGHT

भारतीय मानक

बहुतन्तीय नायोबियम-टाइटेनियम अतिचालक तारें — विशिष्टि

Indian Standard

MULTI FILAMENTARY NIOBIUM-TITANIUM (NbTi) SUPERCONDUCTOR WIRES — SPECIFICATION

ICS 77.120.50 ; 29.030

© BIS 1999

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

May 1999 **Price Group 2**

Specials Metals and Alloys Sectional Committee, MTD 27

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Specials Metals and Alloys Sectional Committee had been approved by the Metallurgical Engineering Division Council.

An ideal superconducting material has zero electrical resistivity if the critical temperature, critical magnetic field and critical current density are not exceeded. With the development of non-ideal type II, NbTi superconductor wire, commercial production of high magnetic field solenoid has become the most useful application of superconducting material. A superconducting solenoid occupies very little space, has no steady-state power consumption, uses relatively little helium coolant and costs approximately one tenth of conventional solenoid installation of similar capacity.

In this standard, the chemical composition of NbTi superconducting wire and the procedure for evaluating its performance for magnetic application has been described.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be same as that of the specified value in this standard.

Indian Standard

MULTI FILAMENTARY NIOBIUM-TITANIUM (NbTi) SUPERCONDUCTOR WIRES — SPECIFICATION

1 SCOPE

This standard covers the requirements for evaluating performance of copper stabilized multi filamentary Niobium-titanium (NbTi) superconductor wires for magnetic applications.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
1387 : 1993	General requirements for the supply of metallurgical materials (*second revision*)
2500 (Part 1) : 1992	Sampling inspection procedure : Part 1 Attributes sampling plans by acceptable quality level (AQL) for lot by lot inspection (*second revision*)

3 SUPPLY OF MATERIAL

3.1 The general requirements relating to supply of this material shall conform to IS 1387.

3.2 Wires shall be supplied in reels/spools.

4 MANUFACTURE

4.1 The choice of manufacturing process is left to the discretion of the manufacturer.

4.2 Raw material used in the manufacture of product shall be inspected and tested to the stipulated requirements of product by the manufacturer before production.

5 CHEMICAL COMPOSITION

The product analysis of the material when carried out by any established instrumental/chemical method shall be as given in Table 1.

Table 1 Chemical Composition

(*Clause* 5)

Constituent	Percent, *Max*
Titanium	45.0-48.0
Carbon	0.02
Iron	0.02
Tantalum	0.01
Nickel	0.01
Silicon	0.01
Copper	0.005
Aluminium	0.01
Oxygen	0.1
Hydrogen	0.002
Nitrogen	0.015
Niobium	Remainder

6 SURFACE CONDITION

The wire surface shall be free from surface defects such as slivers, folds, lamination, dirt, inclusions, oil or water. No superconductor filament shall be visible.

7 MECHANICAL TEST

The wire shall be subjected to tensile test at room temperature (300°K) for determination of ultimate tensile strength and percentage elongation. The requirements and the method of test shall be as agreed between the manufacturer and the purchaser.

8 OTHER REQUIREMENTS

8.1 Conductor Type

Type conductor shall be a composite of oxygen free high conductivity copper NbTi filaments.

8.2 Critical Current

The superconductor shall have a critical current within the specified values. These values refer to a test temperature of 4.224°K and a critical current criterion as δ = 10-14 Ωm based on the total wire cross sectional area and with a magnetic field perpendicular to the wire axis. The method for determination of critical current is given in Annex A.

8.3 Filament Diameter

The equivalent filament diameter shall be in the range of 5 to 50 microns. In order to ensure that the filaments are not electrically coupled, the average spacing between filaments shall be greater than the specified values. The method for determination of filament diameter and spacing is given in Annex B.

8.4 Copper to Superconductor Ratio

The nominal values of the copper to superconductor ratio shall be in the range of 1 to 2.5. The method of determination of copper to superconductor ratio is given in Annex C.

8.5 Resistance at Room and Transition Temperatures

The resistances of wire at room temperature (300°K) and at 10°K (just above the transition temperature of NbTi superconductor) are termed as R_{300} and R_{10} respectively. The method for determination of R_{300} and R_{10} is given in Annex D.

8.6 Residual Resistance Ratio

The wire residual resistance ratio or *RRR* is given by the ratio R_{300}/R_{10} for copper stabilized wires of NbTi.

8.7 Twist Pitch

The wire shall be twisted and the twist pitch of the finished wire shall be in the range of 5 to 100 mm. The wire shall be twisted either as right hand or left hand screw thread as specified by the purchaser.

8.8 Enamelling

The wire shall be enamelled with polyesterimide. The thickness of enamel shall be in the range of 15 to 30 microns.

8.9 Minimum Length

The minimum length of wire shall be determined after all lead and tail defects have been removed by cropping.

8.10 Magnetization Measurement

To evaluate the magnetic response of the wire at low magnetic field region, d.c. magnetization measurement shall be performed and the hysteresis curve showing the relation between applied field (Hin Tesla) Vs. Magnetization (-M in mT) shall be given.

8.11 a.c. Losses

a.c. loss of the superconducting wire is the summation of magnetization loss in superconductor (hysteresis), eddy current loss in the stabilizer and coupling loss between filaments. The measurement of a.c. loss shall be carried out by calorimetric method with a small solenoid.

9 SAMPLING

The sample for testing and inspection shall be selected in accordance with IS 2500 (Part 1).

10 PACKING AND MARKING

10.1 The reels/spools of wires shall be suitably wrapped so as to prevent any damage or deterioration during handling, transportation or storage. These shall also be packed in wooden cases to avoid damage during transit. The internal diameter of reels/spools and their maximum weight shall be mutually agreed upon between the purchaser and the manufacturer.

10.2 The reels/spools and exterior packaging shall be indelibly marked with the following:

a) Indication of the source of the manufacture,
b) Type of superconducting wire and its size,
c) Length in metres,
d) Mass in kg, and
e) Any other information required by the purchaser.

10.3 A test certificate having the necessary details of material and its test report shall be provided by the manufacturer.

ANNEX A

(*Clause* 8.2)

DETERMINATION OF CRITICAL CURRENT BY SHORT SAMPLE METHOD

A-1 DEFINITION OF CRITICAL CURRENT

The *V-I* curve is determined as a function of increasing current till an irreversible transition or quench occurs. This measurement is carried out in specified external field typically 5T or 8T applied normal to the wire axis and in a temperature bath of liquid Helium at 4.224°K/1.8°K . For currents less than the quench current the *V-I* curve is reversible. The critical current is defined as that current at which the resistance per unit length *R*, is

$$R = 10^{-8} \frac{(\pi d^2)}{4} \text{ ohms/metre}$$

where *d* is the diameter of the wire in mm.

The effective resistivity of the wire is 10^{-14} ohm-metre.

A-2 SAMPLE TESTING

The critical current shall be measured at both ends of each continuous length of wire at the specified field values and at 4.224°K and/or 1.8°K. If the temperature of 4.224°K and/or 1.8°K are not available, measurements may be made at other temperatures and precise conversion factors must be applied.

A-3 SAMPLE MOUNTING

The sample wire shall be mounted on a cylindrical grooved former having a diameter more than 20 times of the wire diameter. The former shall be made of G-10 or equivalent glass fibre reinforced epoxy. The two grooves are formed as helical and as parallel to each other to enable the sample of a bifilar mounting arrangement. The diameter between the grooves shall be approximately two times of the wire diameter. Details on the grooves and the sample mountings are shown in Fig. 1.

Two lengths of the sample wire are jointed to each other on the underside of the former and jointed to electrodes on the upper side of the former. The joint length is more than 50 mm. Voltage lead wires are laid under the sample wire. The length between the voltage taps is more than 250 d^2 mm. The length between voltage tap and the joint is more than 50 mm so that the current transfer voltage is reduced to a negligible level.

A-4 PROCEDURE

The sample length '*l*' between the voltage taps shall be determined with the following equation:

$$l = 250\, d^2 \text{ mm}$$

where *d* is the diameter of wire in mm.

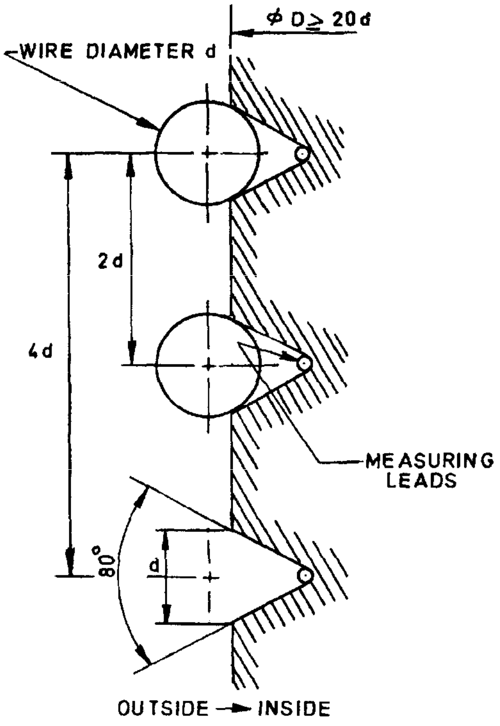

FIG. 1 WIRE SAMPLE HOLDER

The amplifier signal shall be recorded on *X-Y* recorder or on a digital memory device. The *V-I* curve shall be taken continuously with a stable well filtered power supply. The current shall be measured with an accuracy of 0.1 percent. The voltage from the two lengths shall be measured simultaneously or individually. The two measurements of the critical current are averaged to determine the critical current. The quality index n, shall be estimated by using the following equation:

$$V = \text{constant}.I^n$$

A-5 MAGNETIC FIELD

The external field is typically applied by means of a superconducting solenoid. The field must be uniform over the sample length to be within ± 0.5 percent. The direction between the field and wire axis must be 90 ± 3° everywhere. This range of angles corresponds to a variation smaller than 0.5 percent of *I*c.

A-6 TEMPERATURE CORRECTION

The Standard temperature 4.224°K is that of boiling Helium at standard atmospheric pressure. The bath temperature must be recorded with the aid of appropriate thermometry with a , precision of ± 0.01°K. The method of correcting *I*c temperature shall be notified by the purchaser.

ANNEX B

(*Clause* 8.3)

DETERMINATION OF FILAMENT DIAMETER AND SPACING

B-1 DEFINITION OF EQUIVALENT FILAMENT DIAMETER AND AVERAGE SPACING

The equivalent filament diameter, d_{eq}, is defined with the following equation:

$$d_{eq} = 2\sqrt{a/\pi}$$

where a is the cross-sectional area in mm^2.

The average spacing, S_{av}, is defined as an average of the central distance between any adjacent filament pair minus the equivalent diameter, d_{eq}.

B-2 MEASUREMENT

The wire shall be mounted in an epoxy bar in parallel, cut in normal plane, polished and suitably etched to produce a photograph multiplied by more than 1 000 with calibrated scale. Any ten filament cross-sectional area a, and the central distances between adjacent filaments shall be measured.

ANNEX C

(*Clause* 8.4)

DETERMINATION OF COPPER TO SUPERCONDUCTOR RATIO

C-1 Copper to superconductor ratio shall be determined by any chemical process. First, the clean wire sample of 300 mm shall be precisely weighed and then immersed in 50 percent nitric acid solution for 30 minutes in deep petri dish. After the copper is completely etched away, pour acid into an acid container. The remains left in the petri dish are superconductor filaments. Then the filaments shall be gently and carefully rinsed and dried up for 45 minutes. Finally the filaments shall be weighed with a precision of 10^{-4} g.

With this process, copper to superconductor ratio shall be given by the following equation:

$$\text{Copper/Superconductor} = \frac{(\text{Wire wt.} - \text{filament wt.}) \times \text{superconductor density}}{\text{Filament weight} \times \text{copper density}}$$

C-2 Superconductor density shall be measured by chemical etching of copper during the process of wire production. Copper density shall be determined by the density measurement of copper wire having the same contents and processing to the copper stabilizer in superconducting wire.

ANNEX D

(*Clause* 8.5)

DETERMINATION OF RESISTANCES AT 300°K and 10°K

D-1 DEFINITION OF RESIDUAL RESISTANCE RATIO

The residual resistance ratio of copper stabilized NbTi wire is defined as follows:

$$\text{For stabilized NbTi wire } RRR_{\text{NbTi}} = \frac{R_{300}}{R_{10}}$$

Where R_{300} and R_{10} are the wire resistances at 300°K and 10°K respectively. The temperature 300°K is typical room temperature and 10°K is the just above transition temperature T_c of NbTi.

D-2 RESISTANCE MEASUREMENT

A four lead method shall be used to determine the resistance. The leads and samples are in a variable temperature bath from 300°K to 4.22°K.

Current in the range of 0.1 to 1.0 A shall be provided by a well regulated and filtered d.c. power supply with an accuracy of ± 0.5 percent.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act,* 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards: Monthly Additions'.

This Indian Standard has been developed from Doc : No. MTD 27 (3853)

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002
Telephones : 323 01 31, 323 33 75, 323 94 02

Telegrams : Manaksanstha
(Common to all offices)

Regional Offices :		Telephone
Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110 002	323 76 17 323 38 41
Eastern	: 1/14 C. I.T. Scheme VII M, V. I. P. Road, Kankurgachi CALCUTTA 700 054	337 84 99, 337 85 61 337 86 26, 337 91 20
Northern	: SCO 335-336, Sector 34-A, CHANDIGARH 160 022	60 38 43 60 20 25
Southern	: C. I. T. Campus, IV Cross Road, CHENNAI 600 113	235 02 16, 235 04 42 235 15 19, 235 23 15
Western	: Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400 093	832 92 95, 832 78 58 832 78 91, 832 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE.
FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR.
LUCKNOW. NAGPUR. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM.

Printed at Printograph, New Delh, Ph.: 5726847